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Development of a Multi-Criteria Decision Analysis Tool to Support Selection of Nanomaterial Studies

Nanoinformatics 2010

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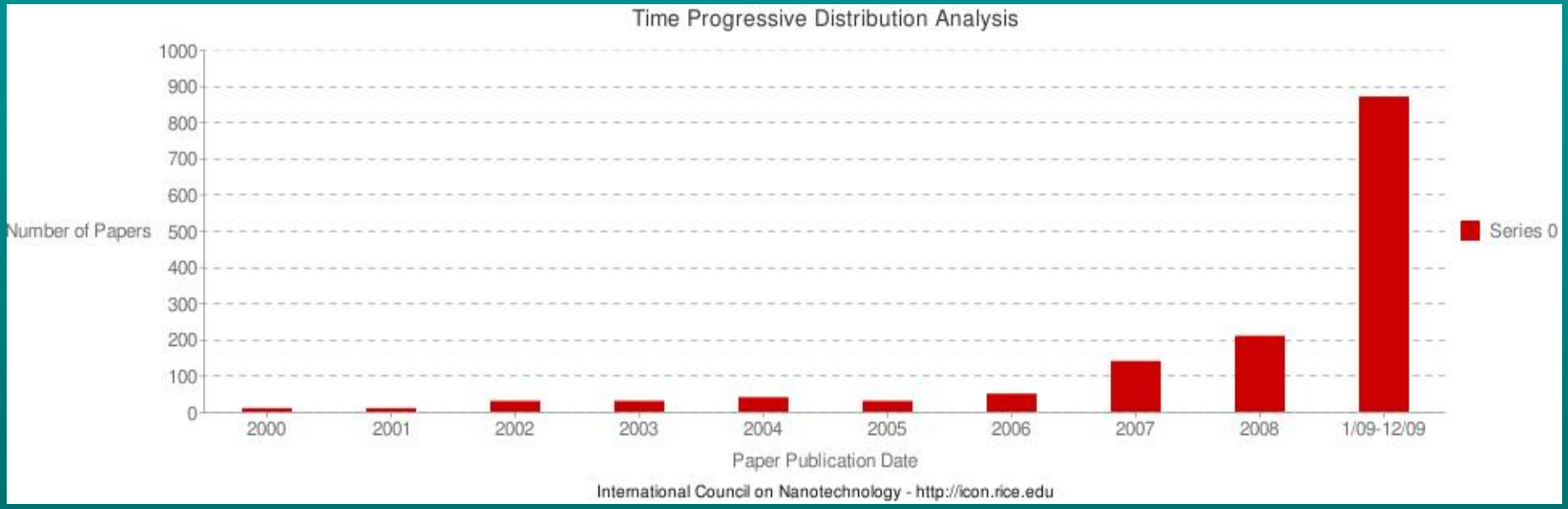
Nanoinformatics 2010 Workshop

*GOAL (*in light of increasing data*):*

"…determining which information is most relevant to the nanoscale science and engineering community."

Hazard assessment studies of nanomaterials are proliferating

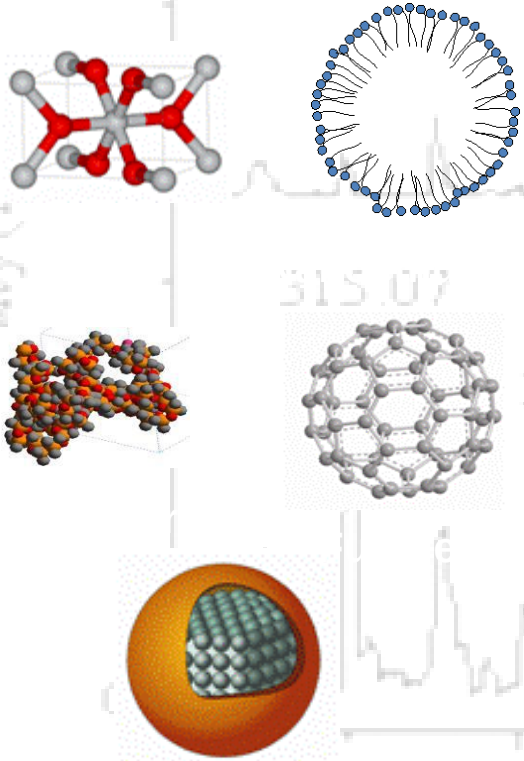


- How can we efficiently identify high quality studies to meet our research needs?

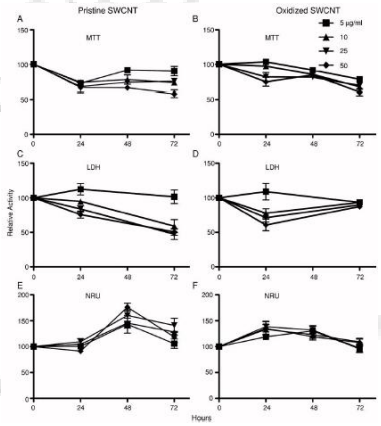
Source: http://icon.rice.edu/report.cfm

Studies measure and report a range of parameters and characteristics

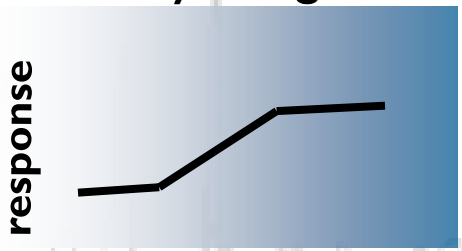
Particle characteristics



Data quality/ presentation



Study design



Images from NCL, 2007

Images from Albini et al 2010. Nanomedicine. 6(2):277-88.

What characteristics or criteria define a study as "high quality"?

Can we develop a tool that allows us to efficiently identify studies that meet these criteria?

Project Objective:

Develop a tool that uses Multi-Criteria Decision Analysis (MCDA) to identify studies that meet defined characteristics

- **MCDA provides a framework to assist decision makers in choosing the best alternative from a range of alternatives amidst conflicting and competing criteria.**
- **Can identify:**
  - Single most preferred option (study) or group of options (studies)
  - Rank options
  - Distinguish acceptable from unacceptable possibilities

?

What will the MCDA tool do?

- Identify the "best" study (or studies) based on study criteria identified as important by the "stakeholders" (researchers, policy makers, etc.)
- Integrated with the Nanomaterial-Biological Interaction (NBI) data repository

Image from http://zumaimaging.net

Project Status

1. **Initial phase—**
   - Seek stakeholder input
   - Develop test version of Tool
   - Establish feasibility of concept
2. **If proof-of-concept established, proceed with development**
   - Refine
   - Program beta version of tool
   - Integrate with databases

Initial Phase: Specific steps

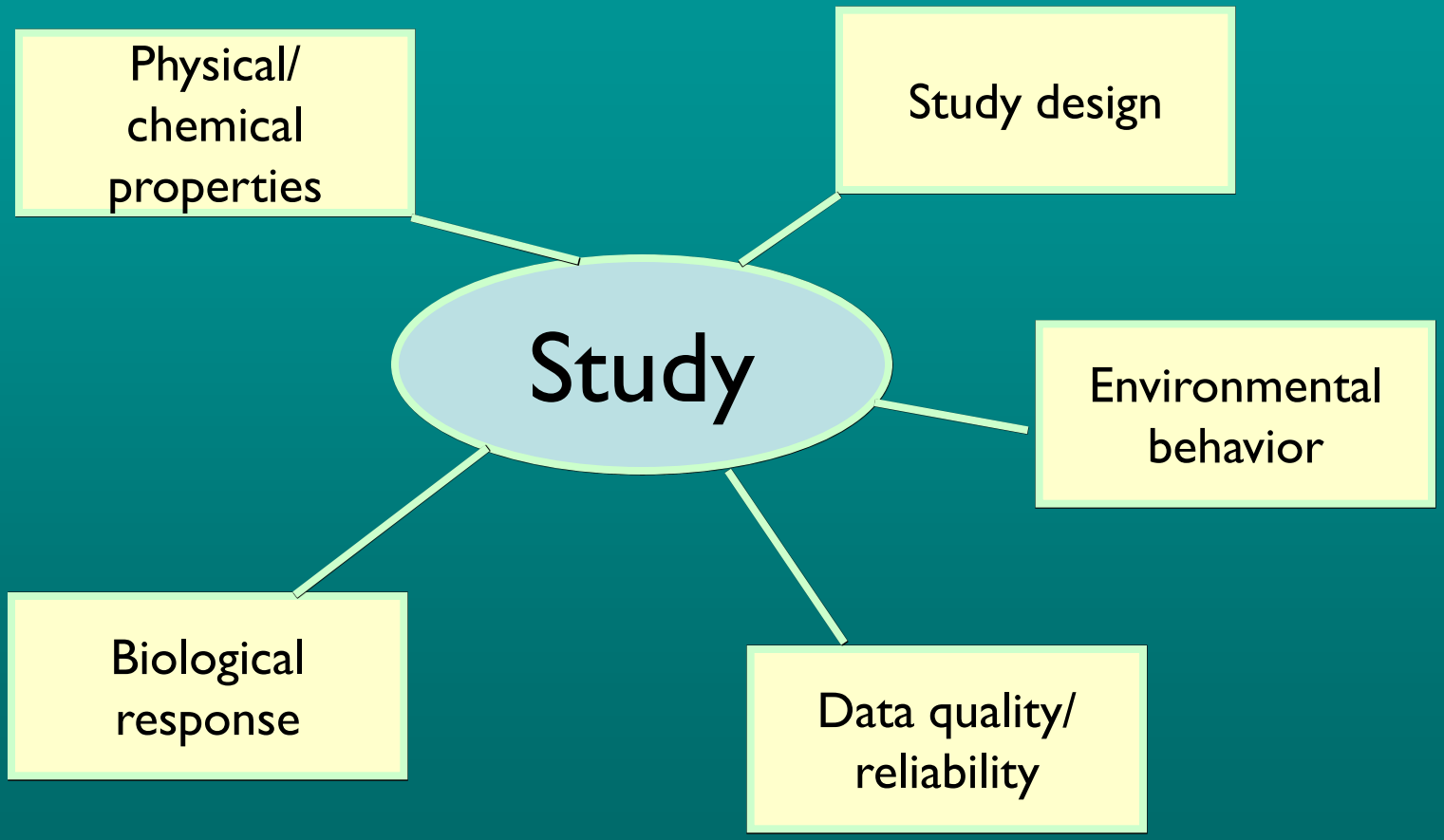
1. Identify stakeholders and goals
2. Identify criteria that define a "quality" study
3. Build a decision framework
4. Rate studies based on criteria
5. Weight relative importance of criteria
6. Integrate results into test version

Identify stakeholders and goals

- Who will use the tool?
- How will they use the information?
- What are their decision criteria for defining a study as useful/ not useful; high quality/ low quality?

Image from http://blogbusinessworld.blogspot.com

Identify criteria that define a "quality study"



Quality/ extent of characterization varies between studies

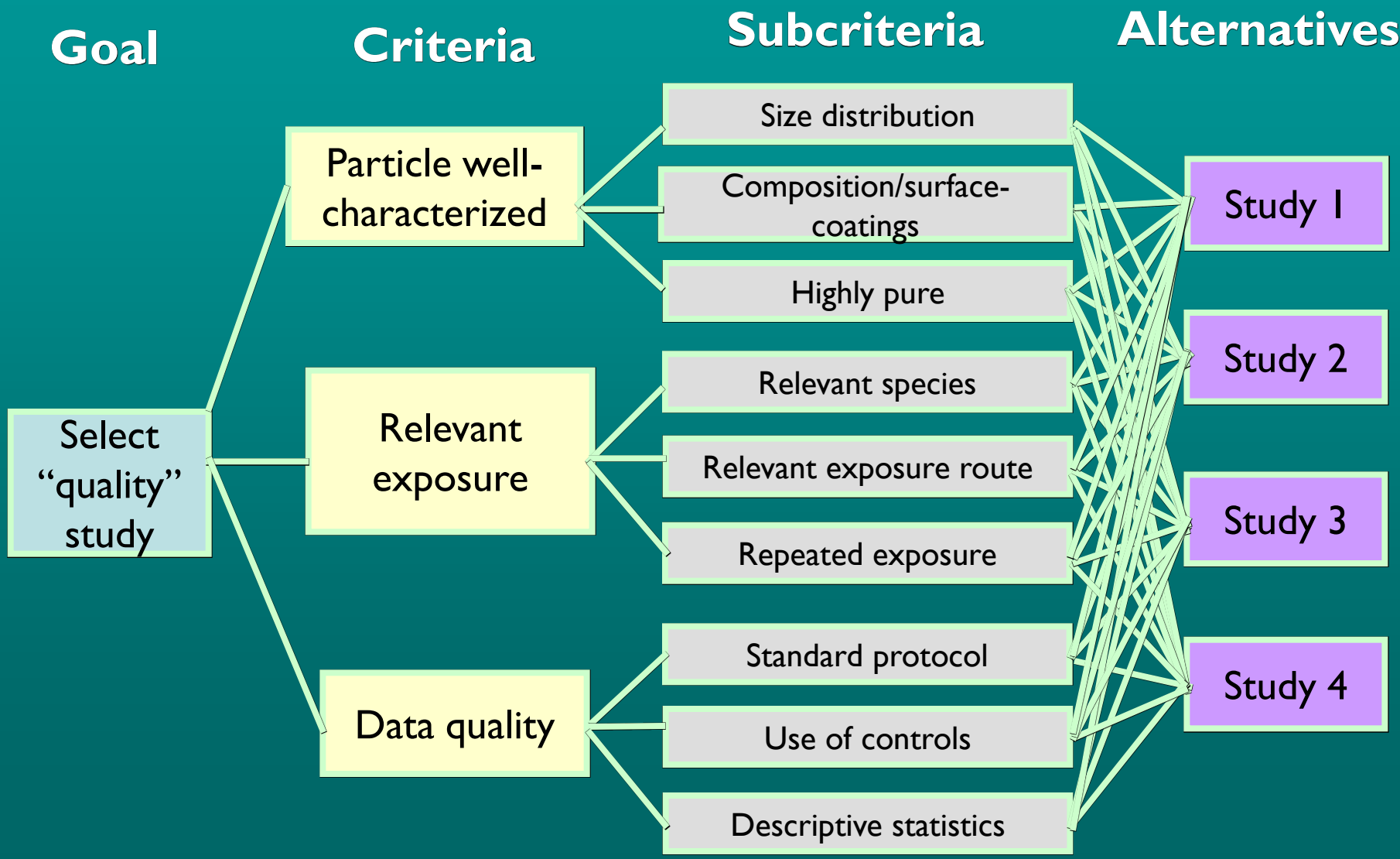
- **Call to develop standardized characterization criteria for hazard identification of nanomaterials**

Material characterization	***In vitro* testing**	***In vivo* testing**	**Environmental fate**	**Data quality**
Particle size/ Distribution	Protocol	Protocol	Persistence	Peer review
Shape	Cell line	Species	Mobility	Independence
Composition	Culture medium	Age/ life stage	Bioavailability	Replicates
Surface chemistry	Assay	Gender	Biomagnification	Positive controls
Surface charge	Concentration	Exposure route	Transformation	Negative controls
Solubility/Dispersibility	Protein binding	Dose		Variability
Aggregate/Agglomerate	Time	# of Subjects		Error
Surface area/Specific surface area	Endpoint	Target organ/ endpoint		Data presentation
		Duration		Statistics
		NOAEL/LOAEL		
		Pathology/ Chemistry		

- **Which criteria are *most important*?**

Source: Oberdörster et al. 2005. Particle and Fibre Toxicology. 2:8; ISO TC229.

Establish relationships between decision criteria and alternatives



Weight the relative importance of criteria

Which do I consider more important…?

- Size distribution well characterized …or… better characterized surface chemistry?
- Standardized protocols…or…More replicates?
- Repeated dosing…or…Relevant exposure pathway?

Weight the relative importance of criteria

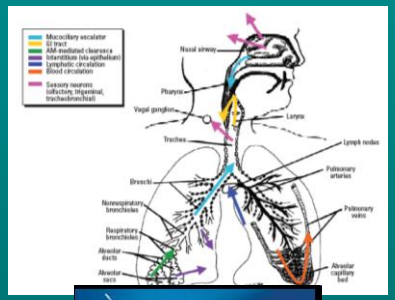
Criteria	Wt	Subcriteria	Wt
Particle well-characterized	**45**	Size-distribution well-characterized	**45**
		Composition/ surface-coatings well-characterized	**40**
		Highly pure	**10**
Relevant exposure	**25**	Relevant species	**25**
		Relevant exposure route	**20**
		Repeated exposure	**10**
Data quality	**30**	Standard protocol	**25**
		Use of controls	**30**
		Descriptive statistics	**20**

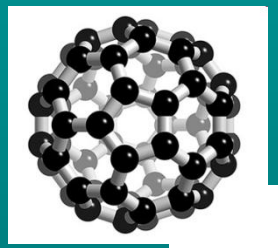
Rate studies

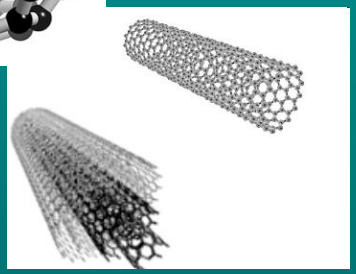
- **Mine databases of nanomaterial studies**

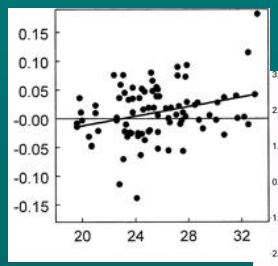
Rate studies

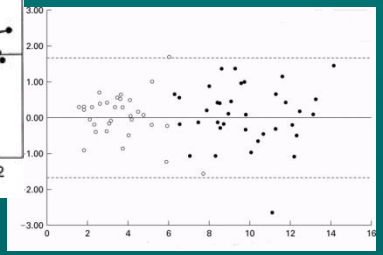
Assessments may be factual or subjective











Images from mavimo.org; 3dchem.com; esd.ornl.gov ; thorax.bmj.com; ocregister.com; mattk.com; opticsplanet.com; Oberdorster et al., 2005; topnews.in

Rate studies

Subcriteria	Study 1	Study 2	Study 3	Study 4
Size-distribution well-characterized	5 Best	3	2	1 Worst
Composition/ surface-coatings well-characterized	5 Best	1	1 Worst	3
Highly pure	4	3	5	3
Relevant species	4	5	2	5 Best
Relevant exposure route	2	5	3	3
Repeated exposure	3	5 Best	2	1 Worst
Standard protocol	4	3	1 Worst	3
Use of controls	1 Worst	5 Best	2	4
Descriptive statistics	2	3	2	4

1 = worst, 5 = best

Integrate results

Subcriteria	Wt	Rating				Score			
		S1	S2	S3	S4	S1	S2	S3	S4
Size-distribution well-characterized	45	5	3	2	1	225	135	90	45
Composition/ surface-coatings well-characterized	40	5	1	1	3	200	40	40	120
Highly pure	10	4	3	5	3	40	30	50	30
Relevant species	25	4	5	2	5	100	125	50	125
Relevant exposure route	20	2	5	3	3	40	100	60	60
Repeated exposure	10	3	5	2	1	30	50	20	10
Standard protocol	25	4	3	1	3	100	75	25	75
Use of controls	30	1	5	2	4	30	150	60	120
Descriptive statistics	20	2	3	2	4	40	60	40	80
Totals						**805**	**765**	**435**	**665**

Moving forward…

- Determine stakeholder priorities and define key criteria
- Integrate data and develop test version of Tool
- Establish Proof-of-Concept
  - Refine
  - Develop

Questions?

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